Gulf General Atomic
Incorporated

GA-9860

FINAL REPORT OF APPRAISAL PROGRAMS AT CHACO CANYON, NEW MEXICO AND PETRIFIED FOREST

by

G. F. Poole and R. G. Sudak

Prepared under
Contract 14-10-4: 940-165
for the
National Park Service
U. S. Department of the Interior

December 1969

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P.O. Box 608, San Diego, California 92112

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INTRODUCTION

This is the final report of appraisal programs conducted at Chaco Canyon National Monument and Petrified Forest National Park for the National Park Service, U. S. Department of the Interior, under Contract No. 14-10-4: 940-165.

The purpose of these appraisal programs was to demonstrate the use of reverse osmosis to provide good quality water at the subject test sites from existing water supplies. This was being done to provide water users within these parks with good quality water in keeping with government standards.

The appraisal programs were conducted during the period from October 29, 1969 to November 8, 1969. During this period adequate data was logged to satisfy the needs of the contract.

TEST FACILITY DESCRIPTION

Reverse Osmosis Test Unit

The Gulf General Atomic reverse osmosis test unit is trailer mounted and consists of pretreatment equipment, the high pressure pumps and spiral-wound modules. The test unit is shown in Figure I. Hose connections are available for the feed, product and brine. Electrical connectors for 230 volts, 3-phase power and 110 volt, single phase power are also bulkhead mounted.

The pretreatment equipment is located in the right front corner of the trailer and consists of 2 chemical addition pumps, 2 full capacity cartridge filters (nominal 25 microns) and a pH controller.

One chemical addition pump is used to adjust the feedwater pH to a nominal value of 5 while the other pump is available for addition of other chemicals as may be required. Operation of the acid addition pump is controlled through the pH controller.

Following pretreatment the feedwater is routed to the pressure vessels containing the submergible pumps. The pumps are in series and are capable of delivering 5 gpm at 520 psi TDH. The pressurized water is then routed through a pump discharge valve where final adjustment is made to module operating pressure. From these the feedwater is routed to 2 module pressure vessels in parallel. The brine discharge from these pressure vessels is manifolded to the final module pressure vessel. Product water from the 3 pressure vessels is manifolded and discharged through the bulkhead hose nozzle. Brine from the final pressure vessel is discharged through a backpressure regulator and the bulkhead hose connection. Each of the module pressure vessels contain 3 Model 4000

ROGA® spiral-wound modules with a nominal 50 ft^2 of membrane area each. The spiral-wound module is shown conceptually in Figures II and III and the modules installed in a pressure vessel are shown in Figure IV.

The test unit has a nominal capacity of 4000 gallons per day when operating with a feedwater of 77° F and recovering 50% of the feedwater as product water. The recovery is limited by the exit brine flow from the last pressure vessel which should be maintained above 2.5 gallons per minute to mitigate the effects of concentration polarization.

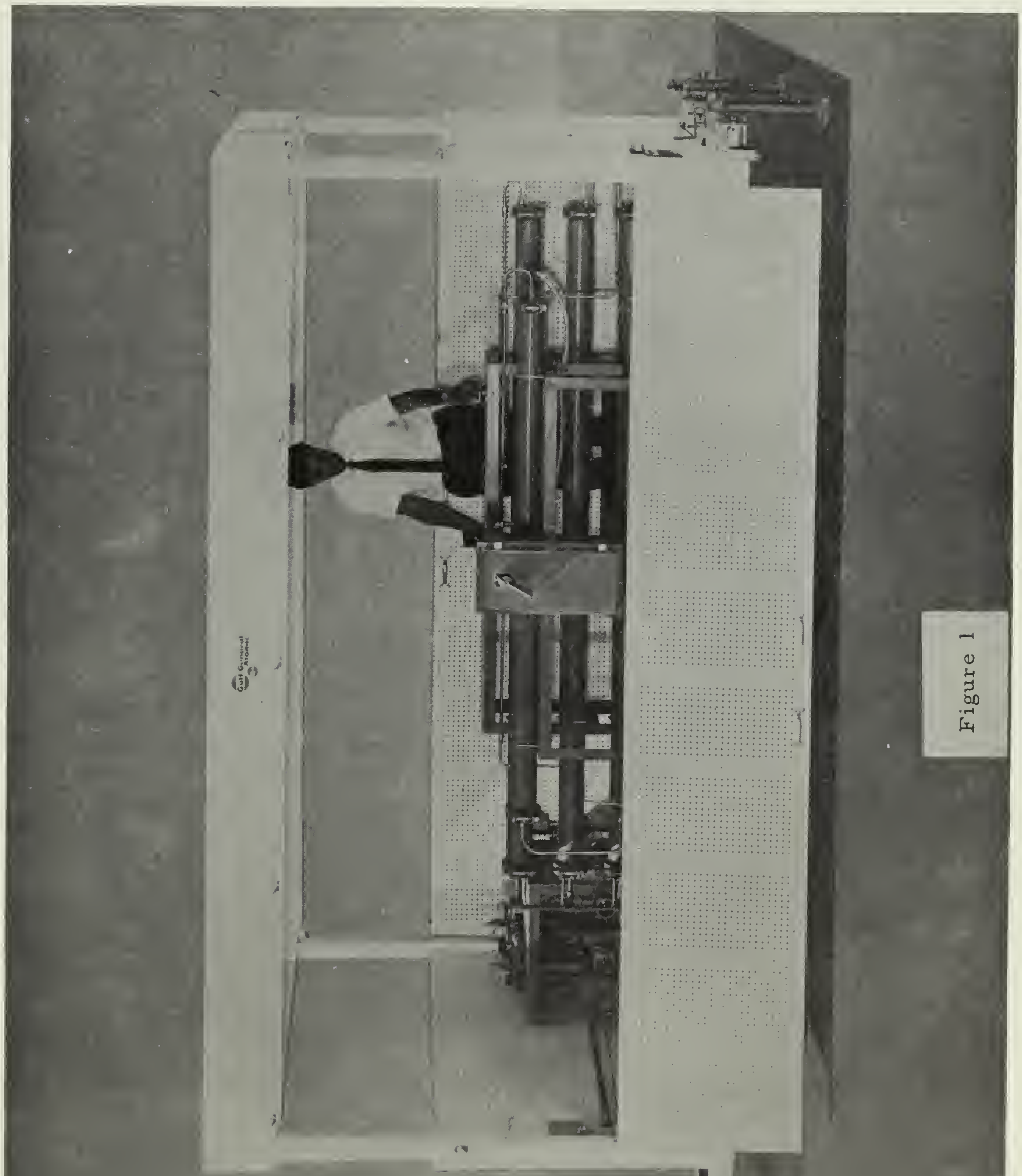


Figure 1

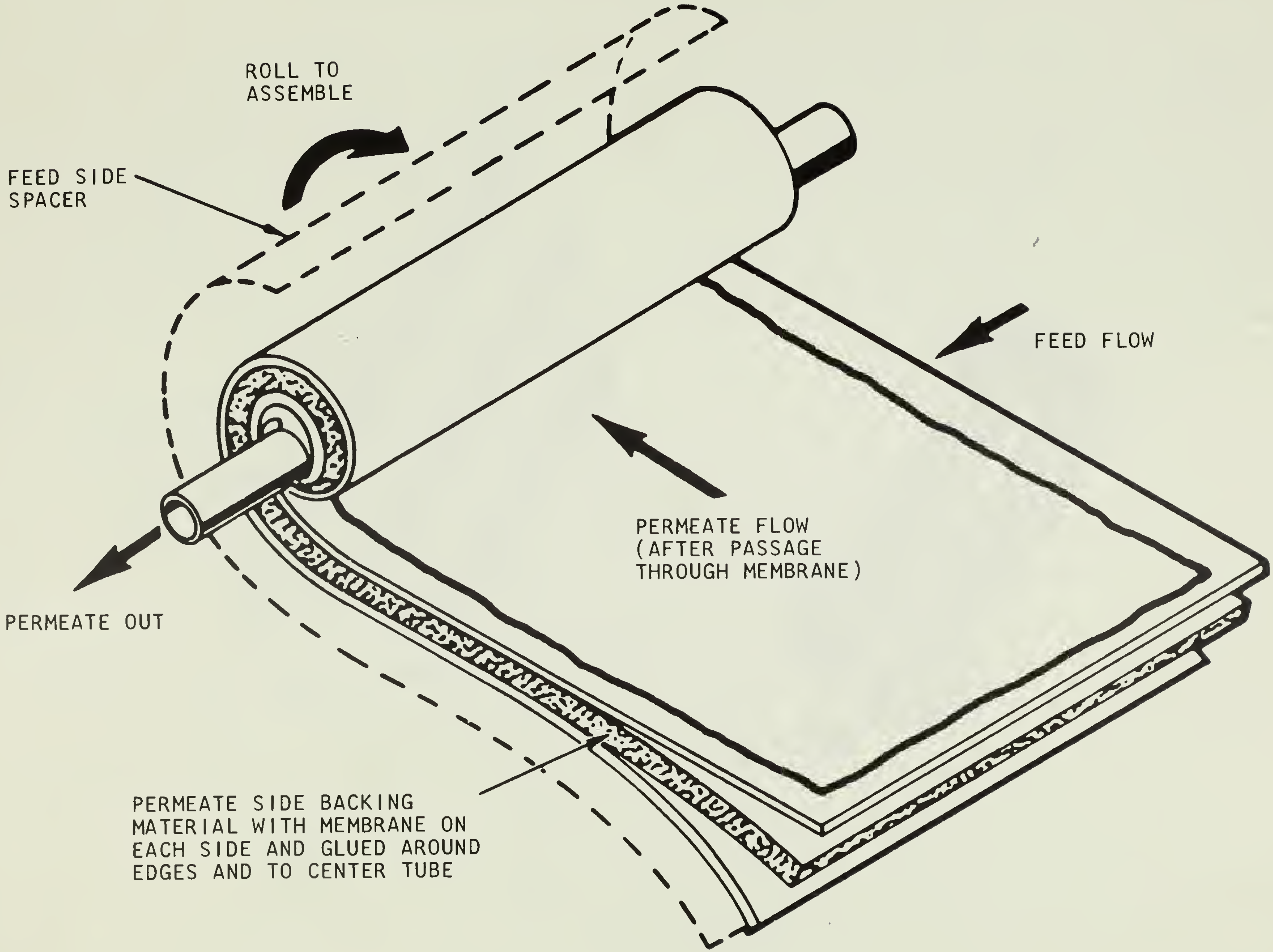
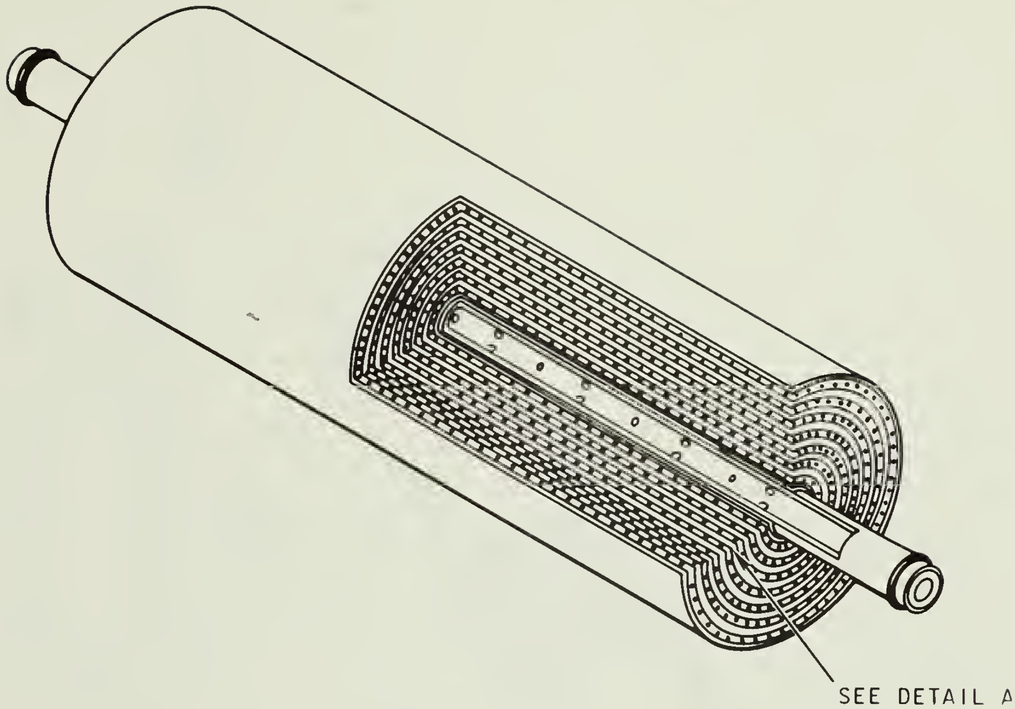

ROLL TO
ASSEMBLE
FEED SIDE
SPACER
FEED FLOW
PERMEATE FLOW
(AFTER PASSAGE
THROUGH MEMBRANE)
PERMEATE OUT
PERMEATE SIDE BACKING
MATERIAL WITH MEMBRANE ON
EACH SIDE AND GLUED AROUND
EDGES AND TO CENTER TUBE

Figure 2


SEE DETAIL A

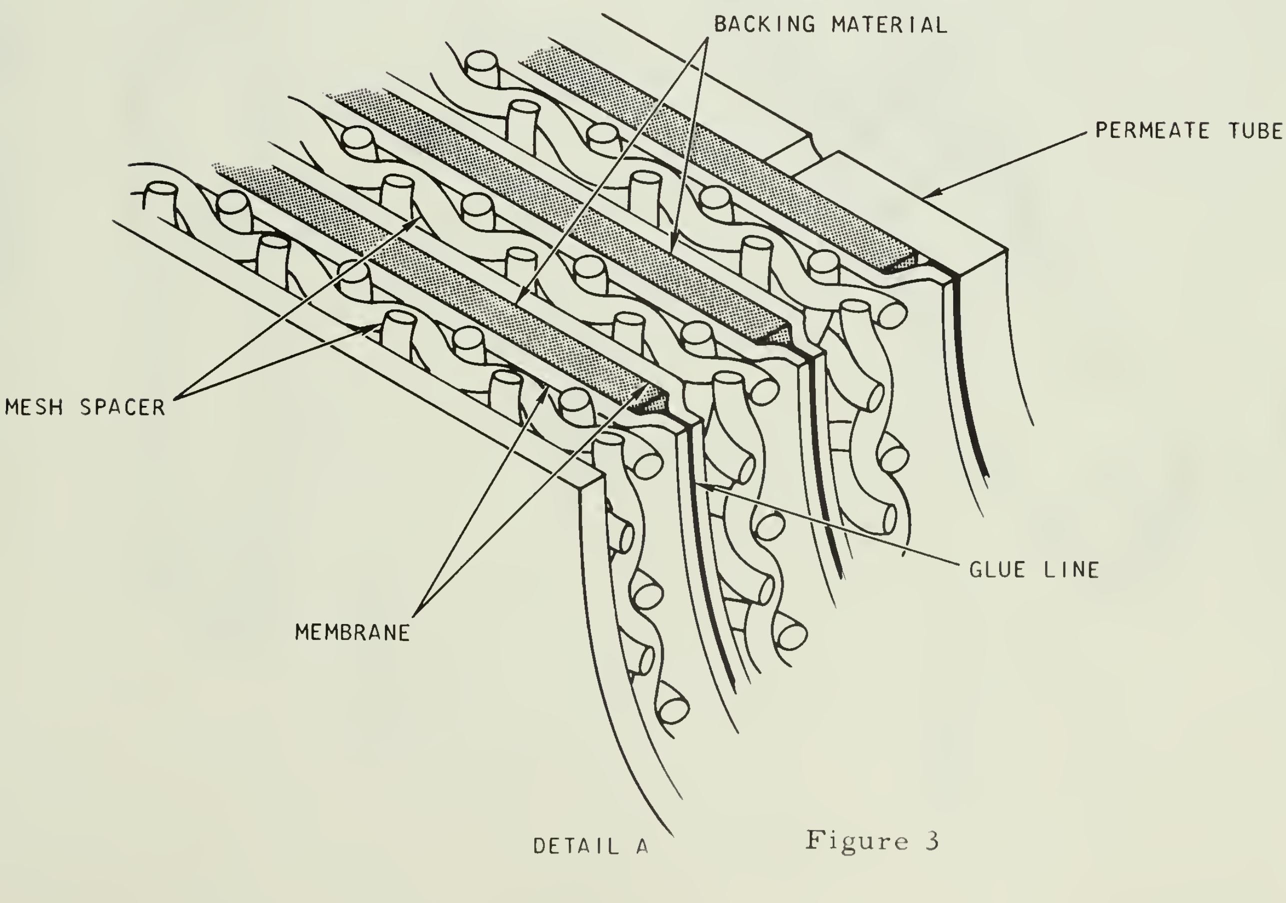

BACKING MATERIAL
PERMEATE TUBE
MESH SPACER
GLUE LINE
MEMBRANE
DETAIL A

Figure 3

MODULE PACK ASSEMBLY

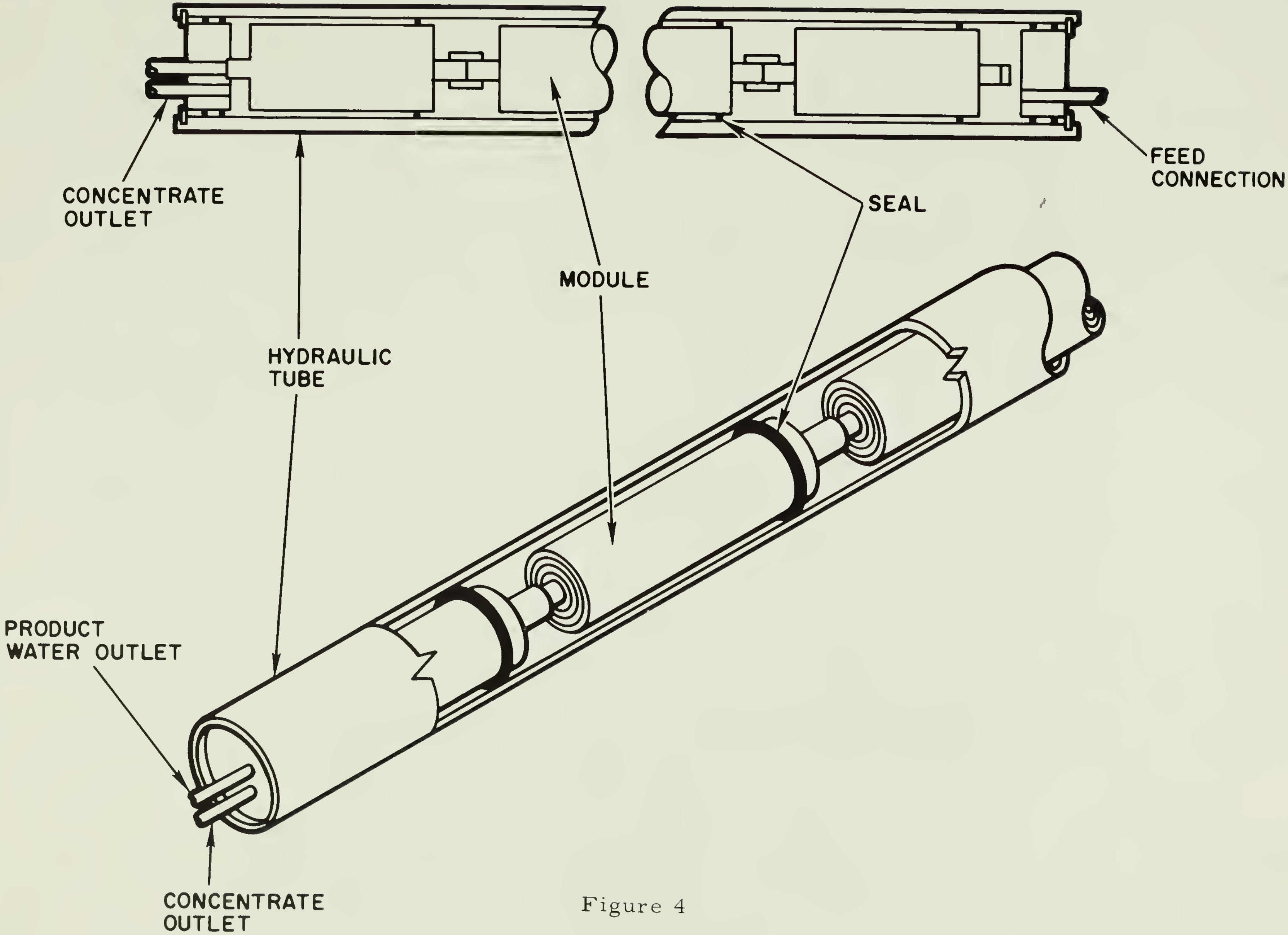


Figure 4

CHACO CANYON INSTALLATION

At Chaco Canyon the trailer was located adjacent to the existing well head building as shown in Figures 5, 6 and 7. The existing water line was disconnected and well pump discharge was directly connected to the trailer feedwater hose connection. Product water and brine from the trailer were discharged through hoses to a nearby gully for disposal.

PETRIFIED FOREST INSTALLATION

At Petrified Forest the trailer was located in the building which is presently used for a vehicle wash rack as shown in Figures 8, 9 and 10. Feedwater was taken from the local water supply. Both product water and brine were discharged to the flow drain in the building.

Figure 5

Figure 6

Figure 7

Figure 8

Figure 9

Figure 10

TEST PROGRAM

Chaco Canyon

In accordance with the agreed upon schedule the Gulf General Atomic test trailer and representative arrived at Chaco Canyon National Monument on the morning of October 29, 1969. It was anticipated that operation of the reverse osmosis unit would begin that day and continue through the evening of October 31. However, the only electrical power available was 220 volt, single-phase— Although 220 volt, 3-phase power is required for the main centrifugal pumps. The National Park Service obtained the necessary phase converter which was installed on November 3, 1969 at which time test operations were initiated. Due to this delay it was mutually agreed that the test program be shortened with no detrimental effect on the data to be obtained.

Operating data are shown in Table 1. Samples of unacidified feed, brine and product were taken and returned to San Diego for chemical analysis by an independent laboratory. The results of this analysis are shown in Table II.

Petrified Forest

On completion of testing at Chaco Canyon National Monument the trailer was moved to the Petrified Forest National Park. The trailer arrived on site on the morning of November 6, was located in the building, and test operations initiated the same day. Test data are shown in Table III while the results of chemical analyses of the unacidified feed, brine and product are shown in Table IV.

TABLE I

CHACO CANYON

Date	11/4	11/4	11/5
Time	1145	1500	0900
Pressure, psig	420	420	460
Temperature, ^{o}F	64	64	67
Feed Conductivity umhos/cm	2000	2000	1970
Brine Conductivity umhos/cm	4300	4350	3830
Product Conductivity umhos/cm	122	107	87
pH	5.0-6.2	5.0-6.2	5.0-6.2
Brine Flow, gpm	2.6	2.6	3.0
Product Flow, gpm	2.7	2.7	2.8
Recovery	51%	51%	48%
Rejection	97.2%	97.6%	97.8%

TABLE II

Chemical Analyses

Chaco Canyon

	mg/l		
	Unacidified Feed	Brine	Product
Calcium	1	2	0
Magnesium	1	2	0
Sodium	510	980	19
Potassium	4. 2	7. 3	0. 3
Carbonate	68	0	0
Bicarbonate	683	220	34
Chloride	65	105	18
Sulfate	306	1758	0
Nitrate	0. 09	0. 11	0. 04
Ortho Phosphate	0	0	0
Fluoride	9. 5	15	0. 98
Iron	0. 85	0. 38	0. 01
Manganese	0	0	0
Boron	0. 4	0. 36	0. 23
Silica	7. 0	14	1. 4
Total Hardness	6	13	0
Total Alkalinity	670	180	28
Total Dissolved Solids*	1644	2860	50
pH	9. 2	6. 1	5. 6
Specific Conductivity µmhos/cm @ 25° C	2185	4310	100

* Dried at 185° C.

TABLE III

Petrified Forest

DATE	11/6	11/7	11/7	11/7	11/8
TIME	1730	0900	1300	1700	0600
Pressure, psig	495	495	495	495	495
Temperature, ^oF	64	64	64	64	59
Feed Conductivity µmhos/cm	1260	1300	1340	1310	1180
Brine Conductivity µmhos/cm	2680	2620	2590	2600	2480
Product Conductivity µmhos/cm	76.7	74.9	74.8	74.0	68.1
pH	4.5-6.5	4.4-6.5	4.8-6.4	5.4-6.4	5.4-6.4
Brine Flow, gpm	2.7	2.8	2.8	2.8	2.8
Product Flow, gpm	2.8	2.8	2.8	2.8	2.7
Recovery	51%	50%	50%	50%	49%
Rejection	96.8%	96.9%	96.9%	96.9%	97.0%

TABLE IV

Chemical Analyses

Petrified Forest

	Unacidified Feed (mg/l)	Brine (mg/l)	Product (mg/l)
Calcium	32	52	0
Magnesium	5.8	9.7	0
Sodium	340	600	18
Potassium	4.8	5.9	0.3
Carbonate	0	0	0
Bicarbonate	537	309	24
Chloride	120	175	19
Sulfate	170	1094	0
Nitrate	2.0	3.1	1.0
Ortho Phosphate	0.07	0.14	0
Fluoride	1.2	2.2	0.3
Iron	0.06	0.03	0
Manganese	0	0	0
Boron	0.6	0.8	0.5
Silica	18	26	3.4
Total Hardness ($CaCO_3$)	104	170	0
Total Alkalinity ($CaCO_3$)	440	254	20
Total Dissolved Solids*	1060	1850	50
pH	8.0	6.6	5.4
Specific Conductivity µmhos/cm @ 25° C	1550	3200	100

* Dried at 185° C.

CONCLUSIONS

The chemical constituents of the well water, brine and product water are shown in Tables II and IV for Chaco Canyon National Monument and Petrified Forest National Park, respectively. Appendix A contains the recommendations of the United States Public Health Service as to the maximum concentration of chemical constituents in potable water. It can be clearly seen that present water supplies at both locations do not meet Public Health Service recommendations. However, it has been clearly demonstrated that the reverse osmosis process will produce a product water which is far superior in quality to that outlined in Appendix A.

APPENDIX A

Public Health Service
Drinking Water Standards
1962 Revision

5.21 The following chemical substances should not be present in a water supply in excess of the listed concentrations where, in the judgement of the Reporting Agency and the Certifying Authority, other more suitable supplies are or can be made available.

Substance	Concentration in mg/l
Alkyl Benzene Sulfonate (ABS)	0.5
Arsenic (As)	0.01
Chloride (Cl)	250.
Copper (Cu)	1.
Carbon Chloroform Extract (CCE)	0.2
Cyanide (CN)	0.01
Fluoride (F)	(See 5.23)
Iron (Fe)	0.3
Manganese (Mn)	0.05
Nitrate (No_3)	45.
Phenols	0.001
Sulfate (SO_4)	250.
Total Dissolved Solids	500.
Zinc (Zn)	5.

5.22 The presence of the following substances in excess of the concentrations listed shall constitute grounds for rejection of the supply:

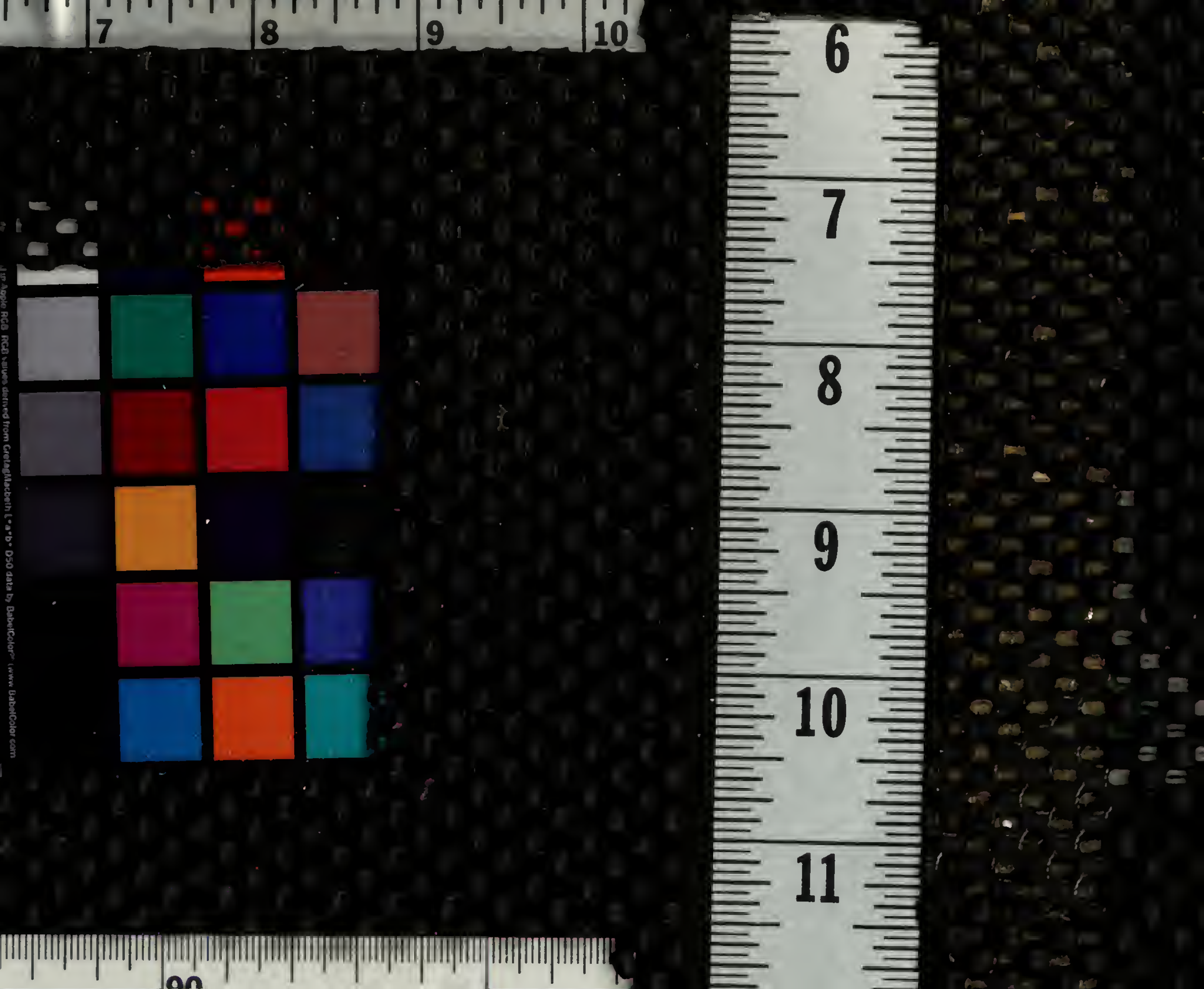
Arsenic (As)	0.05
Barium (Ba)	1.0
Cadmium (Cd)	0.01
Chromium (Hexavalent) (Cr^{+6})	0.05
Cyanide (CN)	0.2
Fluoride (F)	(See 5.23)
Lead (Pb)	0.05
Selenium (Se)	0.01
Silver (Ag)	0.05

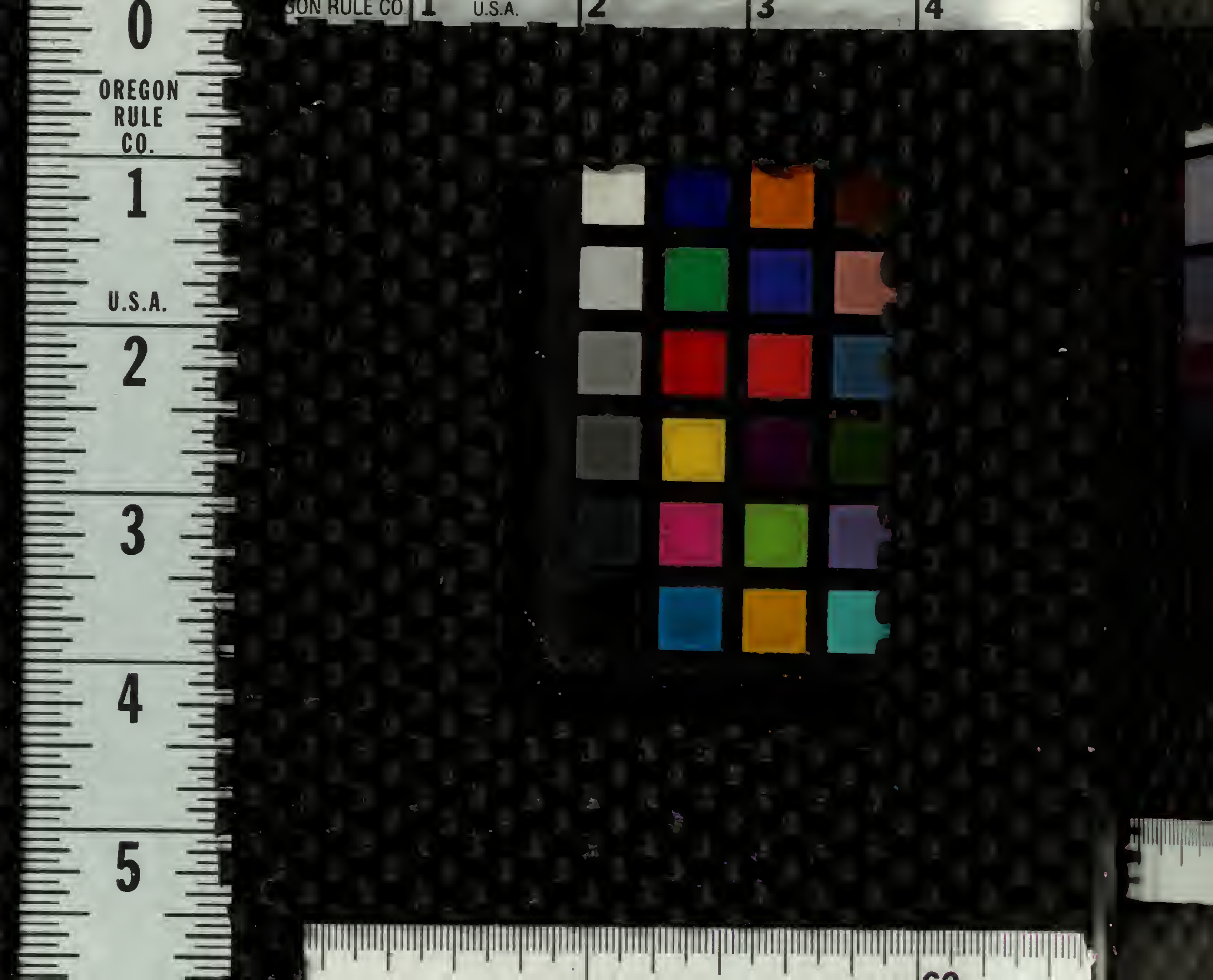
5.23 Fluoride. — When fluoride is naturally present in drinking water, the concentration should not average more than the appropriate upper limit in Table I. Presence of fluoride in average concentrations greater than two times the optimum values in Table I shall constitute grounds for rejection of the supply.

Where fluoridation (supplementation of fluoride in drinking water) is practiced, the average fluoride concentration shall be kept within the upper and lower control limits in Table I.

TABLE I

Annual average of maximum daily air temperatures	Recommended control limits — Fluoride concentrations in mg/l		
	Lower	Optimum	Upper
50.0-53.7	0.9	1.2	1.7
53.8-58.3	0.8	1.1	1.5
58.4-63.8	0.8	1.0	1.3
63.9-70.6	0.7	0.9	1.2
70.7-79.2	0.7	0.8	1.0
79.3-90.5	0.6	0.7	0.8




OREGON RULE CO.
U.S.A.